GLOBE Program™ Teacher's Guide

™

Second Edition, 1996

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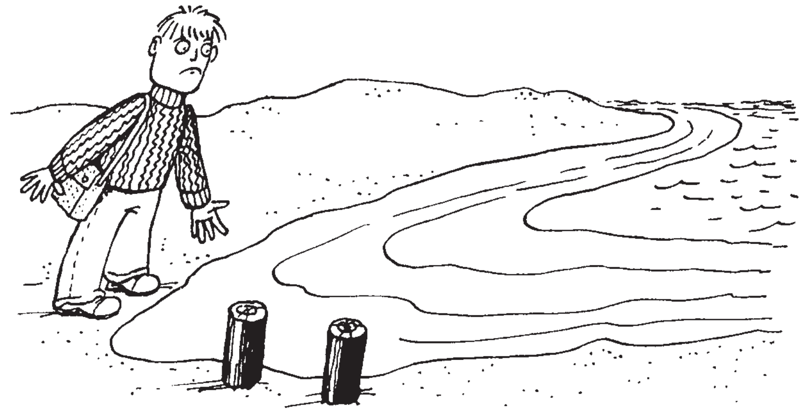
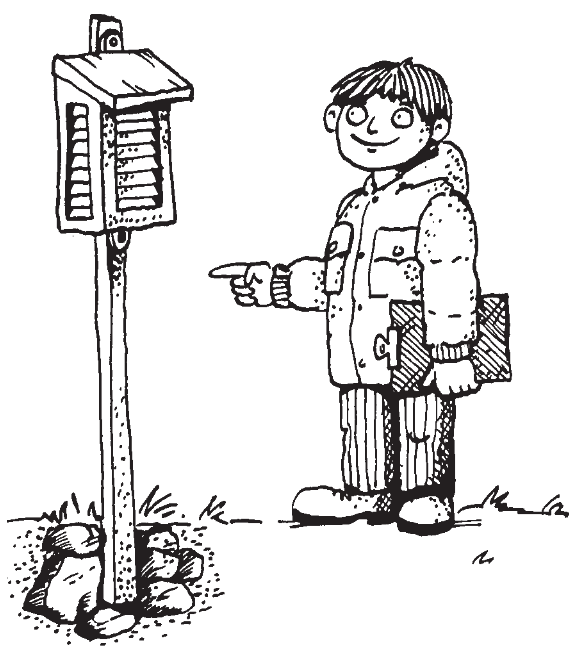
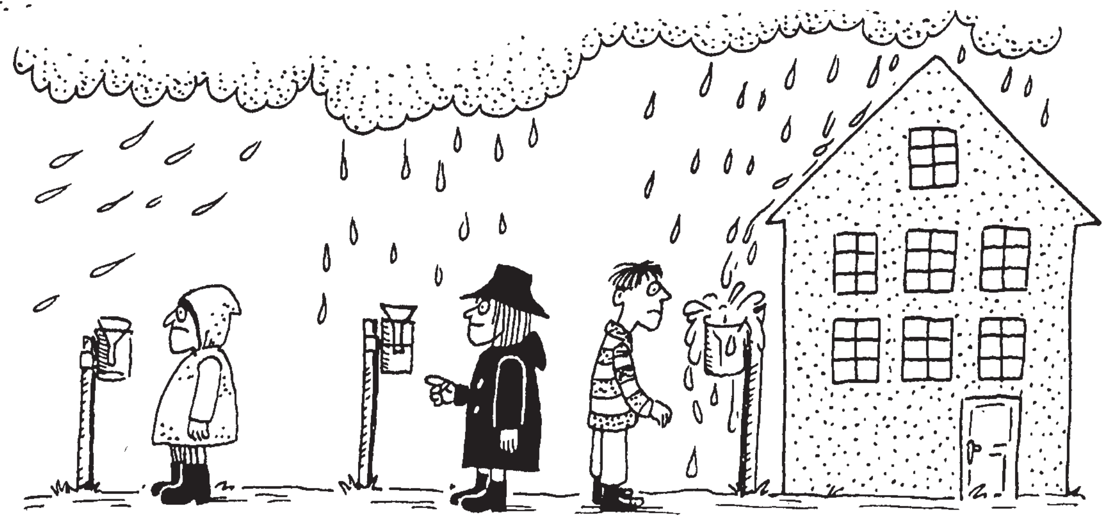






Source: Jan Smolík, 1996, TEREZA, Association for Environmental Education, Czech Republic

Master List of Science and Thinking Skills

observing

asking questions

hypothesizing

designing...
- experiments
- protocols

identifying...
- patterns
- correlations
- relationships
- interconnections

classifying

estimating

predicting

describing

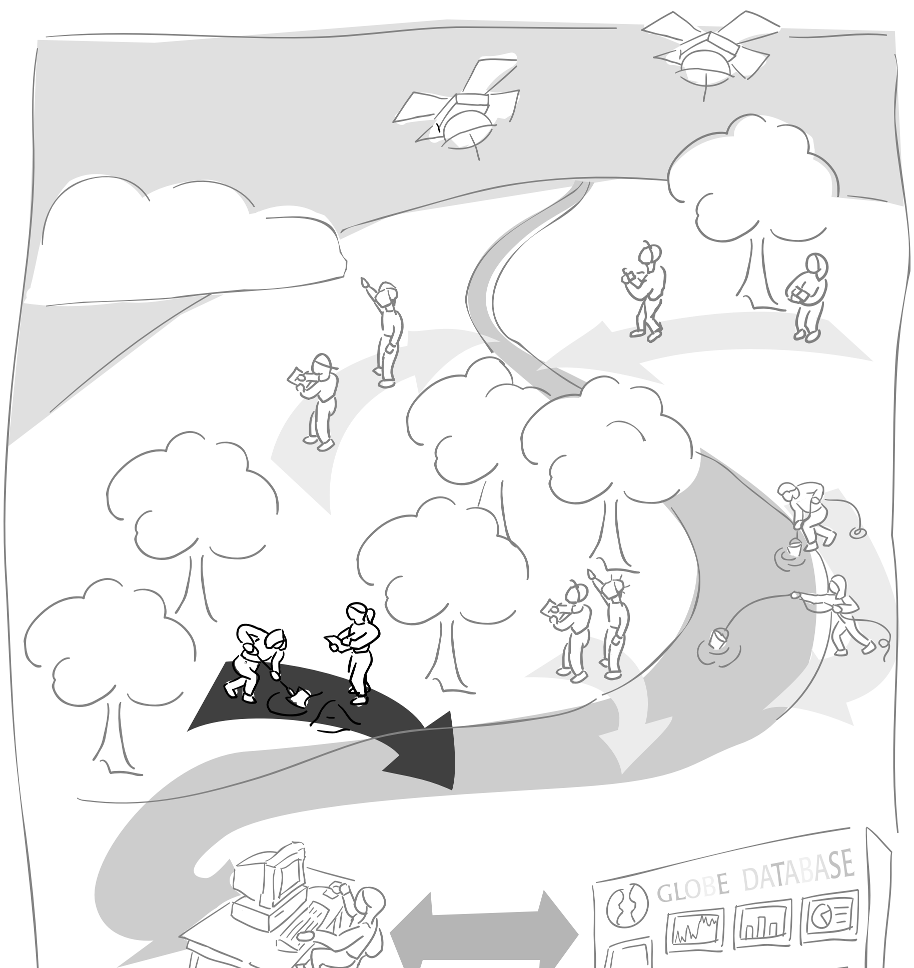
mapping

working with instruments:
- *measuring*
- *calibrating*
- *testing*

working with data:
- *mapping* data
- *graphing* data
- *collecting* data
- *recording* data
- *organizing* data
- *verifying* data
- *analyzing* data
- *summarizing* data

communicating skills:
- *writing* reports
- *communicating* findings
- *communicating* in writing
- *communicating* orally
- *communicating* with graphics

Soil Investigation



A GLOBE™ Learning Investigation

Soil Investigation at a Glance

Protocols

Measurements made at two sites once a year:
- the structure, consistence, color, texture and horizons of the soil
- the pH of the soil horizons
- the percentage of sand, silt, and clay in the soil horizons
- slope (in degrees)

Monthly measurements:
- soil moisture.

Suggested Sequence of Activities

Read Welcome to the Soil Investigation.
Copy and distribute to your students the scientists' letters and interviews.
Read the Protocols to learn precisely what is to be measured and how.
Read The Learning Activities at a Glance at the beginning of the Learning Activities section.
Do the first four activities before beginning the protocols.
Make copies of the data sheets in the Appendix.
Perform the Soil Characterization protocols.
Perform the Soil Moisture protocol.
Visit the GLOBE World Wide Web site with your students and review the data submission pages for Soils.
Submit your data to the GLOBE student data server.
Do the remaining learning activities.

Special Notes

You may require help to dig your soil pit, if you choose to dig one.

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Scientists' Letters to Students

Duplicate and distribute to students.

This investigation consists of two interrelated investigations. Soil Characterization, led by Dr. Elissa Levine, examines soil properties. Soil Moisture, led by Dr. Jim Washburne, examines the moisture in the soil.

Hello Students!

I am Elissa Levine and I am a Soil Scientist for the National Aeronautics and Space Administration (NASA). I am excited to be working with you.

People ask me, “Isn’t soil just dirt? Who cares?” It’s my favorite question. We take soils for granted, yet soils are among our most important natural resources. The ecosystem depends critically on soils. Soils allow water, energy and heat to flow through them, and they are essential for our food and clothing. We walk on soils, play on them, drive on them and construct homes, schools and buildings on them.

As a girl, I was fascinated by the color of soil, the way it felt, and all the rocks, roots and creatures living in it. As I grew up, I became concerned with feeding people and the proper use of our natural resources. So I studied soils.

What does a Soil Scientist do at NASA? I work at the Goddard Space Flight Center in Maryland. Our orbiting spacecraft carry sensors that send us images of the Earth, and I help to explain what the images reveal about the Earth’s surface.

Together, we will determine what your soil looks like, why it looks that way, and how we can manage it for a healthy environment. You will closely examine soil samples from your study site.

Scientists will use your data to learn about the different soils across the Earth. Your data will help us to better interpret our satellite images and to better understand how systems interact on Earth and to predict what will happen to the soil in the future.

Have fun digging and exploring!

Elissa Levine

Dr. Elissa Levine
NASA/Goddard Space Flight Center
Greenbelt, Maryland, U.S.A.

Duplicate and distribute to students.

Dear Students,

Hi, my name is Jim Washburne. I am a research hydrologist at the University of Arizona in Tucson. Hydrology is the study of water and its movement through the atmosphere, soil and the underlying rocks. I am the scientist responsible for GLOBE soil moisture measurements.

When I was young, I was fascinated by how scientists discovered and tracked the movement of continents and the spreading of ocean floors from mid-ocean ridges. I feel the same level of excitement today in studying the Earth's water. New discoveries are being made daily but many questions remain unanswered.

People used to study the Earth piece by piece – looking at either soil, water, air, plants or animals. Now that we better realize how complex the Earth is, we know that it is important to study the whole system and the interconnections between the parts.

I am trying to understand how the water cycle works in dry areas of the world by asking questions like:

- When it rains, how much water remains in the soil and for how long?
- How does human activity affect the water cycle?
- How accurate are satellite data and can they be used in hydrologic models?

Scientists use sophisticated instruments and even satellites to measure soil moisture remotely. Only satellite data when linked with direct, long-term, hands-on ground observations can give us the valuable information we require. This is why we need your help in the field to make direct measurements of soil moisture. By monitoring your GLOBE sites, you will tell scientists what is actually happening on the ground.

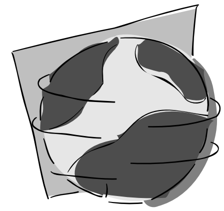
Each one of you can make a difference by making good observations and asking challenging questions. I look forward to working with you. Have fun exploring, measuring, and making sense of your data.

Sincerely,

Jim Washburne

Dr. Jim Washburne
University of Arizona
Tucson, Arizona, U.S.A.

Meet Dr. Elissa Levine and Dr. Jim Washburne



Duplicate and distribute to students.

Dr. Levine: I'm a soil scientist for NASA's Goddard Space Flight Center in Greenbelt, Maryland. Goddard focuses on the Earth and Earth-orbiting satellites. I interpret images from the satellites that tell us about the environment. I also do soil modeling. We put all the soil information into a computer. We then factor in things like the type of vegetation and climate and write equations to describe how water moves through soil or how soils change over time. We try to predict what will happen.

Dr. Washburne: I'm a hydrologist at the University of Arizona. A hydrologist studies water. I'm studying the flows of water from one part of the planet to another. GLOBE fits into my work with NASA's Earth Observing System (EOS). Its goal is to launch the next generation of environmental resource satellites to collect data about the Earth. But as good as these satellites are, soil moisture is difficult to measure from space. There are really no good databases for regional or global soil moisture to check the satellite data.

GLOBE: Soil is just dirt. Why is it important?

Dr. Levine: My favorite question. Soils are one of the most important natural resources that we have. Every part of the ecosystem depends critically on soils. Soils filter water and remove its impurities. The food we eat, the clothes we wear, and many building materials all grow from the soil and depend on its conditions. Water and heat flow through it. It allows nutrients to be stored. Since the soil affects the entire ecosystem, I call it the great integrator.

Dr. Washburne: Soil moisture – the amount of water contained in the soil – is an important factor in determining the kinds of crops, lawns, shrubs and flowers we can grow. Scientists would like to know how soil moisture interacts with the atmosphere and climate.

GLOBE: What questions are you trying to answer with the GLOBE data?

Dr. Levine: What kinds of soils are there around the Earth? What are their properties? How do they relate to the other parts of the ecosystem?

GLOBE: What kind of data do you want from GLOBE students?

Dr. Levine: Students will examine samples of soil from their study site and study them in a variety of ways. I want them to become familiar with soil properties so we'll better understand how moisture flows in soil, how soil relates to vegetation, how it affects the climate, and so on. I'll put their data into my models.

Welcome to the Soil Investigation

Introducing the Big Picture

Soils form a thin layer, called the *pedosphere,* on top of most of the Earth's land surfaces. This thin layer is a precious natural resource. Soils so deeply affect every other part of the ecosystem that they often are called the "great integrator." Soils hold nutrients and water for plants and animals. Water is filtered and cleansed as it flows through soils. Soils affect the chemistry of the water and the amount of water that returns to the atmosphere to form rain. The foods we eat and most of the materials we use for paper, buildings and clothing are dependent on soils.

One of the most important characteristics of any soil is how much water it contains. Either in the form of a vapor or a liquid, water occupies about one-fourth of the volume of a productive soil. All terrestrial life is directly or indirectly dependent on sufficient levels of water in the soils. Soil moisture combines with other properties of the land and climate to determine what kinds of vegetation grow. If the soil gets too dry, it blows away in the wind. Yet if there is too much water, the ground becomes soggy and cannot sustain many crops or, for that matter, the foundations of buildings.

Soils are composed of three main ingredients: minerals of different sizes; organic materials from the remains of dead plants and animals; and open space that can be filled with water and air. A good soil for growing most plants should have about 45% minerals (with a mixture of sand, silt and clay), 5% organic matter, 25% air, and 25% water.

Soils are dynamic and change over time. Some properties, such as temperature and water content (a measure of soil moisture) change very quickly (over minutes and hours). Others, such as mineral transformations, occur very slowly over thousands of years.

Soil formation, or *pedogenesis*, is the result of five key factors. They are:

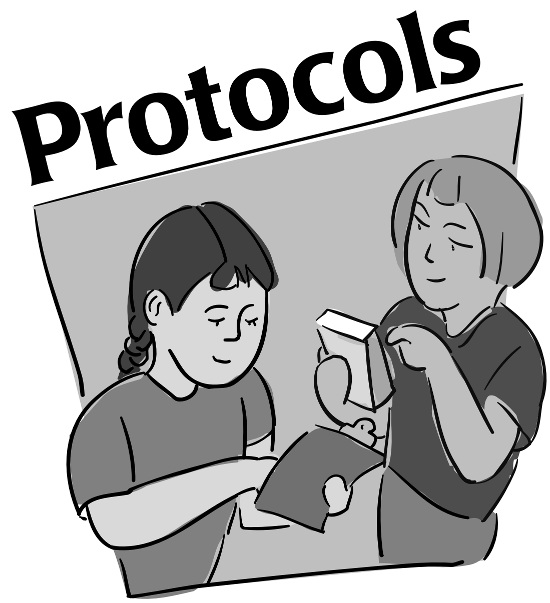
1. parent material – The rocks and minerals that break down into the inorganic particles in soils.

2. climate – The heat, rain, ice, snow, wind, sunshine and other environmental forces that break down the parent material and affect how fast or slow soil processes go.

Figure 5-1

Soil Properties That Change Over Time

Properties that change over minutes or hours	*Properties that change over months or years*	*Properties that change over hundreds and thousands of years*
temperature moisture content composition of air in soil pores	soil pH soil color soil structure soil organic matter content soil fertility microorganisms density	kinds of minerals particle size distribution horizon formation



Part One: Soil Characterization

How to Perform Your Soil Characterization

Students will select their study site and sample soil horizons for examination.

Protocol One: Soil Characterization Field Measurement

Task A: Soil Description

Students will use the Soil Characterization Information Sheet to describe the horizons, color, structure, consistence, and texture of their soil and presence of roots and rocks.

Task B: Obtaining Additional Site Information

Students will collect additional data for their soil study site.

Task C: Collecting Soil Samples

Students will collect soil samples to perform measurements in the classroom.

Protocol Two: Soil Characterization Lab Analysis

Task A: Drying the Samples

Students will dry their soil samples for classroom measurements.

Task B: pH

Students will measure the pH of their soil sample.

Task C: Soil Particle-Size Distribution

Students will determine the percentage of sand, silt and clay in each of the horizons in their soil.

Continued on the following page.

Part One:
How to Perform Your Soil Characterization

Study Site for the Investigation

Soil Characterization requires at least two study sites. One study site should be located next to the Soil Moisture Study Site (see Part Two: Soil Moisture Protocol), and the other should be within the Biology Study Site. At each location, students dig a hole and examine the soil. Obtaining a soil profile to a depth of at least one meter into the ground is preferred.

Frequency

Required to be done only once for each location. Measurements for soil structure, color, texture, consistence, pH, and particle size are made only once at each sample site and the data from each pit are submitted only once.

Additional soil pits may be dug at other locations or in subsequent years if there is an interest in learning more about the distribution of soils in the local area.

Pre-Protocol Preparation: Locating the Site for Your Soil Characterization

Your Soil Characterization study site should be:

- Safe for Digging. Check with local utility companies and maintenance staff to ensure that you do not dig into or disturb a utility cable, water, sewer, or natural gas pipe, or sprinkler irrigation system of some kind.
- Under natural or representative cover. Find a relatively flat location with natural vegetation.
- Relatively undisturbed. Keep at least 3 meters from buildings, roads, paths, playing fields or other sites where the soil may be compacted or disturbed by construction.
- Oriented so that the sun will shine on the soil profile. This will ensure that the soil characteristics are clear for both naked-eye observations and photography.

Exposing the Soil Horizons

Auger Technique

- The objective of this effort is to create on a horizontal surface (the ground) a vertical soil profile. Students are asked to dig a hole down as far as possible but no deeper than one meter. Either a Dutch auger or shovel can be used. Be sure to use the correct auger for your site to examine the soil. A Dutch auger as described in the Toolkit is best for rocky, dry and dense soils. As they dig, each shovelful or augerful of soil will be carefully placed on the ground or on ground cover (a plastic bag, tarp, paper, etc.). As each augerful is removed, it should be placed carefully below the previous one in order to recreate the soil sequence and profile. Enough soil material should be removed to allow sampling for classroom exercises.
- Perform Tasks A, B and C (as described in the Protocol: Soil Characterization–Field Measurement) as soon as possible after the hole is dug. Once these tasks are completed, students should fill in the hole with the original soil.

Soil Pit Technique

- Dig a pit one meter deep and as wide enough around as is necessary to easily observe all

Protocol One:
Soil Characterization Field Measurement

Purpose

To characterize the soils at the selected sites.
To obtain additional site information.
To gather samples from each horizon in order to perform later soil tests in the classroom.

Overview

This protocol is divided into three tasks. In the first task, students will closely examine soils at two sites. Students will be asked to expose a 1 meter deep soil profile for characterization. When this is not possible, a sample 10 cm deep can be taken to use for characterization. In the second task, students obtain additional site information. In the final task, soil samples will be taken to the classroom for further investigation.

Time

For exposing the soil profile, making measurements in the field, and taking samples:

Soil pit including digging–up to one school day;
Auger hole to 1 meter–one or two class periods;
Soil sample from 10 cm depth–one class period.
Allow at least 2 days for drying the soil samples.
Analysis in the laboratory or classroom–one or two class periods.

Level

All

Frequency

Once at each of at least two sites (Soil Moisture Study Site and Biology Study Site)

Key Concepts and Skills

Concepts

- Soil horizon
- Color
- Texture
- Root distribution
- Soil measurements may be influenced by external factors such as land use, general climate, parent material and topography.
- Sampling procedures

Skills

- *Describing* soil characteristics
- *Using* a clinometer
- *Describing* a landscape
- *Collecting* samples
- *Preparing* samples for lab analysis

Materials and Tools

- Trowels
- Shovels
- Dutch auger (See Toolkit for specifications)
- Water bottle with squirt top (e.g. a well-rinsed dish-washing liquid bottle) or atomizer type with a trigger for wetting soil
- Paper or plastic trash bags to lay soil profile on soil color chart
- Tape measure with metric units for estimating layer (horizon) thickness
- 20 nails or golf tees for marking lower and upper boundaries of horizons
- Soil Characterization Data Sheets
- Pencils, clip boards
- Small towel for cleaning hands
- Plastic bags or sealable containers one-liter in size for taking soil samples
- One roll of tape for sealing the sample bags
- A box or bucket for transporting soil samples to the classroom
- One waterproof marker for labeling the sample bags
- Clinometer for measuring slope (same as used in the Land Cover protocol)
- A camera and film for photographing the soil profile and landscape (preferably in color). Slides are acceptable.
- GLOBE Science Notebooks
- Soil Characterization Information Sheet

Preparation

Select the site, gather the tools and materials, arrange to have the hole or pit dug by appropriate persons.

Prerequisites

None

Learning Activities

Soil and My Backyard

Students collect, describe and compare soils from their own backyards.

A Field View of Soil and Soil Moisture - Digging Around

Students discover that soil properties such as moisture and temperature can vary considerably across a single landscape.

The Data Game

Teams of students play a game in which they gather data and distort the values of certain measurements. They then estimate the values of the measurements taken by other teams and try to detect their errors.

Soils as Sponges: How Much Water Does Soil Hold?

Students explore soil moisture by weighing and drying sponges and then they explore their soil samples in the same way.

Soil: The Great Decomposer

Students simulate environmental conditions in order to determine which are the key factors in the decomposition of organic material in soil.

Soil and My Backyard

Purpose
To explore soil and soil properties

Overview
Students will discover the variability of soils, derive relationships among soils and the soil forming factors, and link the GLOBE Soil Investigation to the students' local environment. Students use soil samples from their homes to identify properties that characterize their soils. They compare and contrast their soils to those of their classmates. As a class, students describe relationships between the properties of their soils and how and where they were sampled. Older students construct a soil classification schema.

Time
One class period to observe soil properties and one or two periods for discussion. If soils are to be dried and changes observed, an additional class period will be needed.

Level
All

Key Concepts and Skills
Concepts

Soils vary within a small local area

Soil properties are related to the soil forming factors

Soil can be classified according to its properties

Skills

Sampling of soil

Classifying soil

Materials and Tools
Newspaper

1 liter plastic bags

Local map (topographic or road map which encompasses the school district)

Magnifying glass.

Preparation
On the day of the activity, prepare an area in the room for observing the soils. For example, cover lab tables with newspaper. If students will be drying their samples, you will need to identify a place where soils can be left undisturbed for several days. See the instructions for drying soils in The Soil Protocols – How to Perform Your Soil Measurement.

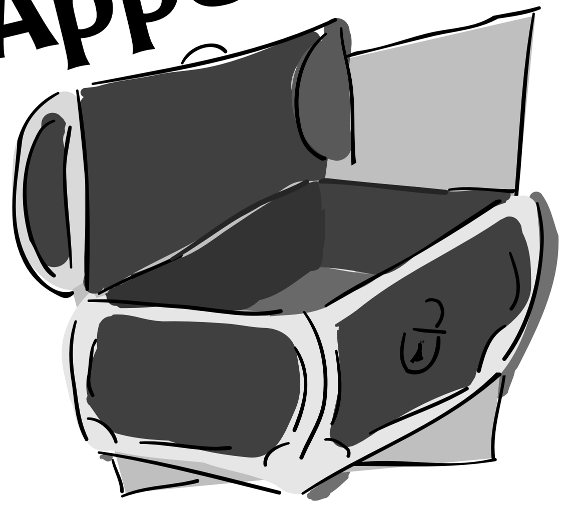
Prerequisites
None

Background
Soils vary in their properties depending on where they have been sampled on a landscape and from what depth they were sampled. As your students examine their soils, help them to think about what they are observing by asking: what properties do they notice? Are the soils wet or dry? What colors do they see? Can they identify the components (organic material [both plant and animal], rock fragments, sand, clay, etc.) of their soils? How does the soil smell? How do the soils feel? How do dry soils differ from the original soil samples? Are there differences within a single soil sample? How does their sampling procedure effect what they see? How would they group or classify their soils?

What To Do and How To Do It
Before Class

Have students bring soil samples from home, using 1 liter plastic bags. They should document their collection methods (such as noting the location from which each sample was taken, the depth of the soil, storage methods, etc.). For younger

Appendix



Soil Characterization Data Work Sheet

Particle-Size Distribution Data Work Sheet

Soil pH Data Work Sheet

Soil Moisture Data Work Sheets:

Near-Surface Soil Moisture
Soil Moisture
Transect Measurements
Daily Gypsum Blocks
Optional Gypsum Blocks Protocol Calibration
Semi-Annual Gypsum Blocks Calibration

Soil Characterization Information Sheet

Textural Triangle

World View of Soil

Glossary

Soil Moisture Data Entry Sheet

Soil Characterization Data Entry Sheet

Site Characterization Study Site Data Entry Sheet

Soil Moisture Study Site Data Entry Sheet